



Procedures and Guidelines

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Responsible Office: 541/Materials Engineering Branch

Title: Goddard Space Flight Center Fastener Integrity Requirements

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PREFACE

1. PURPOSE

The purpose of this document is to define fastener integrity requirements for all fasteners used in flight hardware and for critical nuts and bolts used on ground support equipment, including all flight hardware/GSE interfaces.

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2. REFERENCES

MILITARY STANDARDS

FED-STD-H28/20	Screw-Thread Standards for Federal Services, Inspection Methods for Acceptability of UN, UNR, UNJ, M, and MJ Screw Threads
NAM1312-108	Fastener Test Methods, Metric, Method 108, Tensile Strength
NASM1312-8	Fastener Test Methods, Method 8, Tensile Strength

NASA DOCUMENTS

MSFC-STD-3029	Guidelines for the Selection of Metallic Materials for Stress Corrosion Cracking Resistance in Sodium Chloride Environments
NASA-STD-5003	Fracture Control Requirements for Payloads Using the Space Shuttle
GSFC 731-0005	General Fracture Control Plan for Payloads Using the Space Transportation System
NSS/GO-1740.9	NASA Safety Standard for Lifting Devices and Equipment
NSTS 1700.7	Safety Policy and Requirements for Payloads Using the Space Transportation System
KHB 1700.7	Space Transportation System Payload Ground Safety Handbook
230-WI-5340.2.1	Control of Non-Conforming Project Parts
541-WI-5330.1.15	Verification of Locking Torque and Breakaway Torque Values for Self-Locking Nuts, Nutplates and Hi-Lok/Hi-Tigue Collars at Incoming Inspection
541-WI-5330.1.16	Proof Testing of Flight Hardware Fasteners
547-PG-5330.1.1	Fastener Inspection Test Plan

3. SCOPE

This document is for the use of Goddard Space Flight Center Projects as tailored by the Product Design Lead in conjunction with his Product Design Team. This document is used by Code 200 to assure the integrity of the metric and U.S. Standard fastener inventories at GSFC.

4. DEFINITIONS

Approved manufacturer - An approved manufacturer is a manufacturer that has passed an audit intended to verify that the company's processes and products meet the requirements of applicable specifications.

Audit - An inspection performed at a manufacturer's facility to verify that the company's processes and products meet the requirements of applicable specifications.

Bolt - For the purposes of this document, a category of fasteners including tensile and shear bolts, shoulder bolts, screws, HiLoks, HiTigues, and lockbolts.

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Critical GSE fasteners - Nuts or bolts where a single failure could result in injury to personnel or damage to property or flight hardware by dropping or losing control of the load.

Developer - Any organization that designs or builds flight hardware.

Distributor - An enterprise that stocks the products of various manufacturers for resale and does not engage in manufacturing activity.

Fail safe (STS) or redundant load path (non-STs) - An approach in which the structure is designed with sufficient redundancy so that the failure of one structural element does not cause general failure of the entire structure. The fasteners in a multi-fastener joint of a non-STs payload are considered by this specification to be redundant load paths.

Fastener - items, such as bolts, screws, nuts, anchor nuts, rivets, shear pins, helical and cylindrical inserts, and setscrews, that join components and transfer load.

Material Test Report: A document produced by the fastener manufacturer that certifies information required by the applicable fastener specification. The information typically includes fastener lot number, manufacturing date, lot quantity, raw material heat number, chemical composition and mechanical and metallurgical test results.

Proof test - A test conducted by a single load application to demonstrate the structural integrity of a fastener.

Safe life (STS) or single point failure (non-STs) - An approach where the failure of one element could endanger the success of a mission or could result in injury to personnel or damage to property or flight hardware. NASA-STD-5003 and GSFC 731-0005 require that the largest undetected flaw that could exist in a safe life part will not grow to failure when subjected to the cyclic and sustained loads and environments encountered in four mission lifetimes.

5. AUTHORITIES AND RESPONSIBILITIES

5.1 Project Manager. The Project Manager shall ensure that the provisions of this policy are implemented for Center projects, their contractors, and their sub-tier suppliers.

5.2 Reliability and Quality Assurance. The purchaser's Reliability and Quality Assurance organization shall perform receiving and acceptance testing of all flight hardware and critical GSE fasteners per 9.2.

5.3 System Safety. The purchaser's System Safety organization shall verify that procured flight hardware and critical GSE fasteners meet applicable requirements and that the final status of review is included in the final STS safety package.

5.4 Materials and Processes. The purchaser's Materials and Processes group shall provide assistance to the purchaser's R and QA organization or to the procuring engineer for applications that are not clearly defined by this fastener policy.

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5.5 Contracting Officers. Contracting Officers shall ensure requirements provided by the project manager in response to this specification are included in all applicable contracts.

5.6 Cognizant Engineers. Cognizant engineers shall ensure that drawings for STS payloads are properly identified with respect to safe life fasteners and that drawings for ground support equipment are properly identified with respect to critical nuts and bolts.

6. CANCELLATION

The previous version of this document was S-313-100, "Goddard Space Flight Center Fastener Integrity Requirements", Revision B dated 2-13-98. The previous revision of Appendix A, "GSFC Approved Manufacturers List" was Revision C dated 4-13-98.

7. QUALITY RECORDS

NA

8. IMPLEMENTATION

In this document, a requirement is identified by "shall," a good practice by "should," permission by "may" or "can," expectation by "will," and descriptive material by "is."

Specific requirements are contained in this section. In addition, some of the requirements are summarized in Table I for flight hardware fasteners and in Table II for critical GSE fasteners. Specialized fastener requirements are in section 8.6.

The following products are exempt from the requirements of sections 8.2 through 8.7: washers, spring pins, cotter pins, retaining rings, cable ties, safety wire, and non-metallic fasteners.

8.1 Material Selection. Metallic fastener materials for flight hardware and critical ground support equipment applications shall be selected from Table I, Highly Resistant Materials, of MSFC-STD-3029, Guidelines for the Selection of Metallic Materials for Stress Corrosion Cracking Resistance in Sodium Chloride Environments.

8.2 Approved Manufacturers Products. All safe life (STS) or single point failure (non-STs) flight hardware bolts shall be the products of manufacturers who have been approved by an on-site product audit conducted by the procuring organization (see 8.7). Developers that do not audit manufacturers shall procure the products of GSFC-approved manufacturers (Appendix A). No other fastener types covered by this specification (see Tables I and II) are required to be the products of approved manufacturers. All safe life or single point failure flight hardware nuts and bolts must be size #10 (5mm) or larger. The use of size #8 (4mm) or smaller must approved by the Project's Lead Mechanical Engineer.

Since manufacturers normally do not handle small orders, fasteners often are purchased through distributors. Developers may purchase fasteners from manufacturers or distributors.

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8.3 Material Test Reports. For flight hardware use, each lot of nuts, bolts, helical inserts and cylindrical inserts of size #10 (5mm) and larger and each lot of rivets and shear pins 3/16" diameter (5mm) and larger shall be accompanied by the fastener manufacturer's material test report. Material test reports shall also be obtained for each lot of critical GSE nuts and bolts.

Material test reports are not required for nuts, screws, helical inserts and cylindrical inserts of size #8 (4mm) and smaller nor for rivets and shear pins of size 5/32" (4mm) and smaller nor for setscrews. However, these fastener types shall be procured as unmixed lots to maintain the statistical significance of the sampling plan of section 9.2.1.

8.4 Screening. All nuts and bolts for flight hardware and critical GSE applications, as well as all flight hardware rivets, helical and cylindrical inserts, shear pins, and setscrews shall be subjected to inspection and testing per Table III and 9.2 to check conformity with specification requirements regarding strength and dimensions. The inspections and tests shall be performed by an organization that is independent of the manufacturer and distributor.

8.5 Traceability. The traceability of flight hardware nuts and bolts (size #10 or 5mm and larger), rivets (size 3/16" or 5mm and larger), and critical GSE nuts and bolts shall be maintained into and including stores. Traceability shall include vendor, manufacturer, lot number, and screening level (safe life/single point failure or fail safe/redundant load path).

Traceability shall be maintained into flight hardware and GSE at each project's discretion. Storage of fasteners shall be controlled to assure traceability.

8.6 Specialized Fasteners. The following fastener products shall be evaluated by the procuring engineer and the purchaser's Materials and Processing activity to establish appropriate material, design, processing, and screening requirements: custom manufactured fasteners, pyrotechnic fasteners, eyebolts, clevises, hooks, wire rope, turnbuckles, continuous threaded rod and those not otherwise specified. Test and inspection of certain ground support equipment items is required by NSS/GO-1740.9 and KHB 1700.7.

8.7 Audits. Audits are intended to verify that a company's processes and products meet the requirements of applicable specifications. An audit performed by any branch of the procuring organization is considered valid for the entire organization. Audit approval is limited to the audited location and product and not to affiliated companies nor dissimilar products. An audit is considered valid for a maximum of 3 years, unless quality problems are noted in received hardware or via Alerts.

9. QUALITY ASSURANCE PROVISIONS

9.1 Discrepant Fasteners. Discrepant fasteners shall be dispositioned per the developer's nonconforming material control procedures (230-WI-5340.2.1 at GSFC).

9.2 Screening Inspections and Tests. The screening inspections and tests summarized in Table III shall be conducted on the specified fastener types by an organization that is independent of the manufacturer and distributor. The following information supplements Table III.

9.2.1 Sampling.

9.2.1.1 Approved Manufacturers' Products. Sample size and acceptance criteria shall be as follows for approved manufacturers' products:

Lot Size	Samples	Accept Criteria
1 to 50	2	0 defective
51 to 100	3	0 defective
101 to 500	5	0 defective
501 to 1200	6	0 defective
1201 and over	7	0 defective

9.2.1.2 Non-Approved Manufacturers' Products. Sample size and acceptance criteria shall be as follows for non-approved manufacturers' products:

Lot Size	Samples	Accept Criteria
1 to 50	3	0 defective
51 to 100	5	0 defective
101 to 500	7	0 defective
501 to 1200	8	0 defective
1201 and over	9	0 defective

9.2.2 Visual Inspection.

9.2.2.1 A preliminary visual inspection to assure lot uniformity shall be performed at 1X on the entire fastener lot.

9.2.2.2 Visual inspection for finish and other characteristics requiring visual inspection by the appropriate procurement specification shall be performed at 10X minimum magnification, on a sampling basis per 9.2.1.

9.2.3 Tensile Test.

9.2.3.1 Tensile test per the latest revision of NASM1312-8 Tensile Strength or NAM1312-108 Metric Tensile Strength.

Record ultimate load, or determine and record ultimate strength, whichever is required by the specification. Record the specification minimum for comparison.

9.2.3.2 When bolts or screws are too short to tensile test (when the length is less than 4 times the diameter), perform hardness testing.

9.2.3.3 Saving load plots is not required.

9.2.4 Locking/Breakaway Torques. Locking torque and breakaway torque shall be verified on lot samples of size #10 (5mm) and larger self-locking nuts, nutplates and Hi-Lok/Hi-Tigue collars. Values shall comply with the applicable product specification. Sampling shall be per section 9.2.1. Nuts, nutplates and Hi-Lok/Hi-Tigue collars shall be subjected to one installation /removal cycle only and shall not be subjected to bakeout nor be seated

prior to or during the test. Locking/breakaway torque verification at GSFC shall be performed in accordance with 541-WI-5330.1.15.

9.2.5 Non Destructive Evaluation. One hundred percent (100%) means every safe life or single point failure fastener must be inspected. Acceptable NDE methods include penetrant, eddy current, and magnetic particle inspections and proof testing (9.2.8).

9.2.6 Dimensional Inspection. One hundred percent (100%) means every safe life or single point failure fastener must be inspected. Thread dimensional inspection shall be performed on the threaded products specified in Table III, except helical inserts, to System 21 of FED-STD-H28/20 (go and no go ring or plug thread gauges). Dimensional inspection shall include verifying that the socket depth and head height of socket head cap screws are within specification requirements.

Dimensional inspection of non-threaded products and helical inserts specified in Table III shall consist of measurement to determine that diameter and length conform to specification requirements.

9.2.7 Hardness Test.

9.2.7.1. When a hardness test is required, it shall be performed on the thread end of the bolt or screw, and is considered to be nondestructive. Rockwell Superficial hardness testing may be employed in lieu of Rockwell hardness testing.

9.2.7.2. The purpose of hardness testing safe life or single point failure bolts is to verify that the hardware is of the proper strength. All safe life or single point failure bolts from a given lot, including the tensile test samples, shall be hardness tested. Hardness testing of aircraft style nuts typically is destructive. As a substitute for hardness testing, tensile testing and NDE, safe life or single point failure nuts shall be proof tested on a 100% basis.

9.2.7.3 Hardness test acceptance shall be in accordance with the applicable product specification.

9.2.8 Proof Test. Proof testing of safe life or single point failure fasteners is an established method of verifying structural integrity and may be performed as a substitute for tensile, NDE, and hardness testing. Examples of situations where proof testing may be performed are:

- a. when the cost or availability of custom hardware prohibits destructive tensile testing.
- b. when NDE techniques of the required type or sensitivity are not available or cannot be performed due to processing oversight.
- c. when hardness testing of critical nuts cannot be performed accurately or would be destructive.

Proof testing of fasteners may be performed provided:

Flight Hardware

- a. the proof test is performed in accordance with 541-WI-5330.1.16, Proof Testing of Flight Hardware Fasteners or an equivalent document.

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- b. the proof test load is determined in accordance with:
 - 541-WI-5330.1.16 or
 - a fracture control plan (STS payloads) or
 - the applicable procurement specification or
 - the requester's analysis.
 - c. safe life or single point failure fasteners for a given application are proof tested 100%, not on a sampling basis.
 - d. the fasteners show no yielding as determined by a length measurement.
 - e. a subsequent visual inspection reveals no defects.
 - f. the fastener passes a subsequent thread dimensional inspection.
- Ground Support Equipment
- a. the proof test and subsequent inspections are performed in accordance with NSS/GO-1740.9 or other applicable specifications.

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TABLE I FASTENER PROCUREMENT, DOCUMENTATION, AND SCREENING REQUIREMENTS FOR FLIGHT HARDWARE

FASTENER TYPE (1)	APPROVED MANUFACTURER'S PRODUCT REQUIRED	OBTAIN TEST REPORT	SCREEN
Bolt (2) Single point failure or safe life (3)	X	X	X
Nut Single point failure or safe life (3)		X	X
Bolt (2), Nut or Helical or Cylindrical Insert, Redundant load path or fail safe, #10 (5mm) and larger		X	X
Bolt (2), Nut or Helical or Cylindrical Insert, Redundant load path or fail safe, #8 (4mm) and smaller			X
Rivet or Shear Pin, 3/16" (5mm) dia. and larger		X	X
Rivet or Shear Pin, <3/16" (5mm) dia.			X
Setscrews			X

(1) Exempt: washers, spring pins, cotter pins, retaining rings, ties, safety wire, and non-metallic fasteners.

(2) Category includes bolts, shoulder bolts, screws, HiLoks, HiTigues, and lockbolts.

(3) Usage shall be #10 (5mm) or larger. Use of size #8 (4mm) or smaller shall be approved by the Project's Lead Mechanical Engineer.

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TABLE II FASTENER DOCUMENTATION AND SCREENING REQUIREMENTS FOR GROUND
SUPPORT EQUIPMENT FASTENERS

FASTENER TYPE	OBTAIN TEST REPORT	SCREEN (1)
Critical bolt (2) or nut (3)	X	X
Noncritical fastener		

(1) Applicable screening tests are given in Table III.

(2) Category includes bolts, shoulder bolts, screws, HiLoks, HiTigues, and lockbolts.

(3) Specialized critical fasteners shall be treated per section 8.6.

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TABLE III SCREENING SUMMARY FOR FLIGHT HARDWARE AND CRITICAL GROUND SUPPORT EQUIPMENT FASTENERS (1)

FASTENER TYPE	Visual	Tensile	100% NDE	100% Hardness	100% Dimensional	Locking/breakaway torques (4)	100% Proof test	Dimensional	Hardness
Bolt, Single point failure/safe life (3)	X	X(2)	X(2)	X(2)	X		O(2)		
Nut, Single point failure/safe life (3)	X				X	X(4)	X		
Bolt or Nut, Redundant load path/fail safe, #10 (5mm) and larger	X	X(5)				X(4)		X	O(5)
Bolt or Nut, Redundant load path/fail safe, #8 (4mm) and smaller	X							X	
Rivet, Shear Pin	X							X	X(6)
Helical Insert, Cylindrical Insert, Setscrews	X							X	

X - required testing, O - optional test method, may be substituted for other test methods, see notes.

(1) Inspections/tests are on a lot sampling basis unless otherwise indicated. See sect. 9.2 for supplemental information.

(2) Proof testing is an acceptable substitute for tensile, NDE, and hardness. See section 9.2.8 .

(3) Usage shall be #10 (5mm) or larger. Use of size #8 (4mm) or smaller shall be approved by the Project's Lead Mechanical Engineer.

(4) Self-locking nuts, nutplates and Hi-Lok/Hi-Tigue collars only.

(5) Acceptable to substitute hardness testing on bolts or screws if they are too short to tensile test (when the length is less than 4 times the diameter) or on fail safe or redundant load path nuts.

(6) Hardness test waived on <3/16" (5mm) diameter and on all blind rivets.

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Appendix A: GSFC APPROVED MANUFACTURERS

Safe life or single point failure screws and bolts as defined in section 4. shall be made by these manufacturers or by manufacturers that are audited by the developer. Screws or bolts may be purchased directly from the manufacturer or from any distributor. The following manufacturers typically will produce aerospace bolts and screws to NAS, MS, or NA specifications, as well as custom fasteners.

Air Industries, Garden Grove, CA. (714) 892 5571

Ameritech Fastener Mfg. Inc., Houston, TX (713) 939 7638

B&B Specialties Inc., Anaheim, CA. (714) 985 3000

BEK Level 1 Inc., Huntington, WV (304) 697 2323
NDT certs from BEK Level 1 Fasteners not acceptable.

Bristol Industries, Brea, CA (714) 990 4121

Butler Inc., Gardena, CA (310) 323 3114

California Screw Products, Paramount, CA. (213) 633 6626

CBS Fasteners, Anaheim, CA (714) 779 6368

Champion Fasteners, Inc., Mount Holly, NJ (800) 755 2693

Fairchild Fasteners, City of Industry, CA (626) 369 3333

Fastener Innovation Technology (FIT) Inc., Gardena, CA (310) 538 1111

Fastener Technology Corp., N. Hollywood, CA. (818) 764 6467

Federal Manufacturing Corp., Chatsworth, CA (818) 341 9825

Hi-Shear Corp., Torrance, CA (310) 326 8110

Holo-Krome Co., West Hartford, CT (203) 523 5235

Huck Aerospace Fasteners, Lakewood, CA (310) 830 8200

Ideal Fasteners Inc., Anaheim, CA (714) 630 7840

LFC Industries, Inc., Arlington, TX (817) 640 1322

Maney Aircraft, GS Aerospace Division, Ontario, CA (909) 390 2500

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GSFC APPROVED MANUFACTURERS, continued

J.I. Morris Co., Southbridge, MA (508) 764 4394

MS Aerospace, Burbank, CA (818) 953 9080

Nylok Fastener Corp., Anaheim, CA (714) 635 3993

P.B. Fasteners, Gardena, CA (310) 323 6222

Pilgrim Screw Corp., Providence, RI (401) 274 4090

Quality Aircraft Screw, Corona, CA (909) 270 3210

Rocket Air Supply, Inc., Arlington, TX (817) 640 5340

Saturn Fasteners, Burbank, CA (818) 846 7145

SPS Technologies, Jenkintown, PA (215) 572 3133

SPS Technologies, Salt Lake City, UT (801) 964 4100

SPS Technologies-Western, Santa Ana, CA (714) 545 9311

Twist Tite Mfg. Inc., Santa Fe Springs, CA (562) 407 1733

Valley Todeco, Sylmar, CA (818) 367 2261

Van Petty, Inc., Newberry Park, CA (805) 498 4594

3V Fasteners, Corona, CA (909) 734 4391

West Coast Aerospace, Wilmington, CA (310) 518 3167

This list was derived from DQA Memo 99-262, "Office 5060, Quality Assurance, List of Approved Flight Systems Fastener Suppliers", Jet Propulsion Laboratory, Sept. 29, 1999 and the "Ames Research Center Code Q Index of Surveyed Suppliers", 2000.

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